Space Weather Technical Forecast

Issued on Monday, 26 June 2023 at 13:06 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Isolated R1/R2 Radio Blackouts likely. Slight chance of G1/Minor Geomagnetic Storm conditions on day 2 (27 Jun).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low with a peak C8.5 flare from AR3341 at 24/1218 UTC. This region contains a large H-spot, with a number of very small spots or pores at a distance from the main spot. The most notable and largest region is AR3340 in the northwest. A large asymmetric penumbra is evident in the trailer along with a weak delta spot and harbours the potential for more significant flaring. A minor flare from AR3338 around 25/2030 UTC appears to have resulted in a CME, and is not expected to be significantly Earth-directed. Another minor flare around 25/2145 UTC from AR3346, also in the northwest, resulted in more notable coronal dimming in SDO AIA-211 imagery. It is likely that a CME has resulted from this, with a rather higher chance of being Earth-directed.

Solar Wind / Geomagnetic Activity: The solar wind as measured by DSCOVR at L1, showed the continued signature of a CME arrival, likely a glance from the CME from the X1.1 flare on 20 Jun. Solar winds started at elevated levels around 550km/s and have now declined to 490 km/s. Density was initially above average, with a peak of 12 ppcc, but has lowered to become average to below average. The total IMF strength, Bt, was largely Moderate with a peak of 12nT at 25/1221 UTC, but became Weak late in the UTC day on 25 Jun. The north-south component Bz remained at mostly weak levels. Geomagnetic activity was Quiet to Unsettled (Kp1-3).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as observed by GOES16, was at Background. High energy electron flux (greater than 2MeV), as observed by GOES16 was at Background to Moderate levels with a peak value of 393pfu at 25/1715 UTC. The associated 24-hour fluence showed a steady then largely declining trend through the day, reaching 1.22e7 integrated pfu at 26/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Low to Moderate, with isolated M-class flares likely and a slight chance of activity reaching Strong levels.

Solar Wind / Geomagnetic Activity: A CME may glance Earth late on day 1 (26 Jun) or more likely on day 2 (27 Jun), from the M4.8 flare and associated filament eruption from AR3341 on 22 Jun. It is possible that further Earth-directed CMEs may have left the sun late on 25 Jun. Currently slightly elevated solar winds will probably decline to around 400 km/s in the next 24 hours. Further coronal hole sourced enhancements are then possible from day 2 (27 Jun) onward however these are low confidence. Geomagnetic activity is expected to be Quiet to Unsettled before activity becomes Unsettled to Active, with a slight chance of G1 Minor Storms. This is most likely on day 2 (27 Jun) with any slight coronal hole enhancement between days 2 to 4 (27-29 Jun) or any possible CME arrivals through the guidance period.

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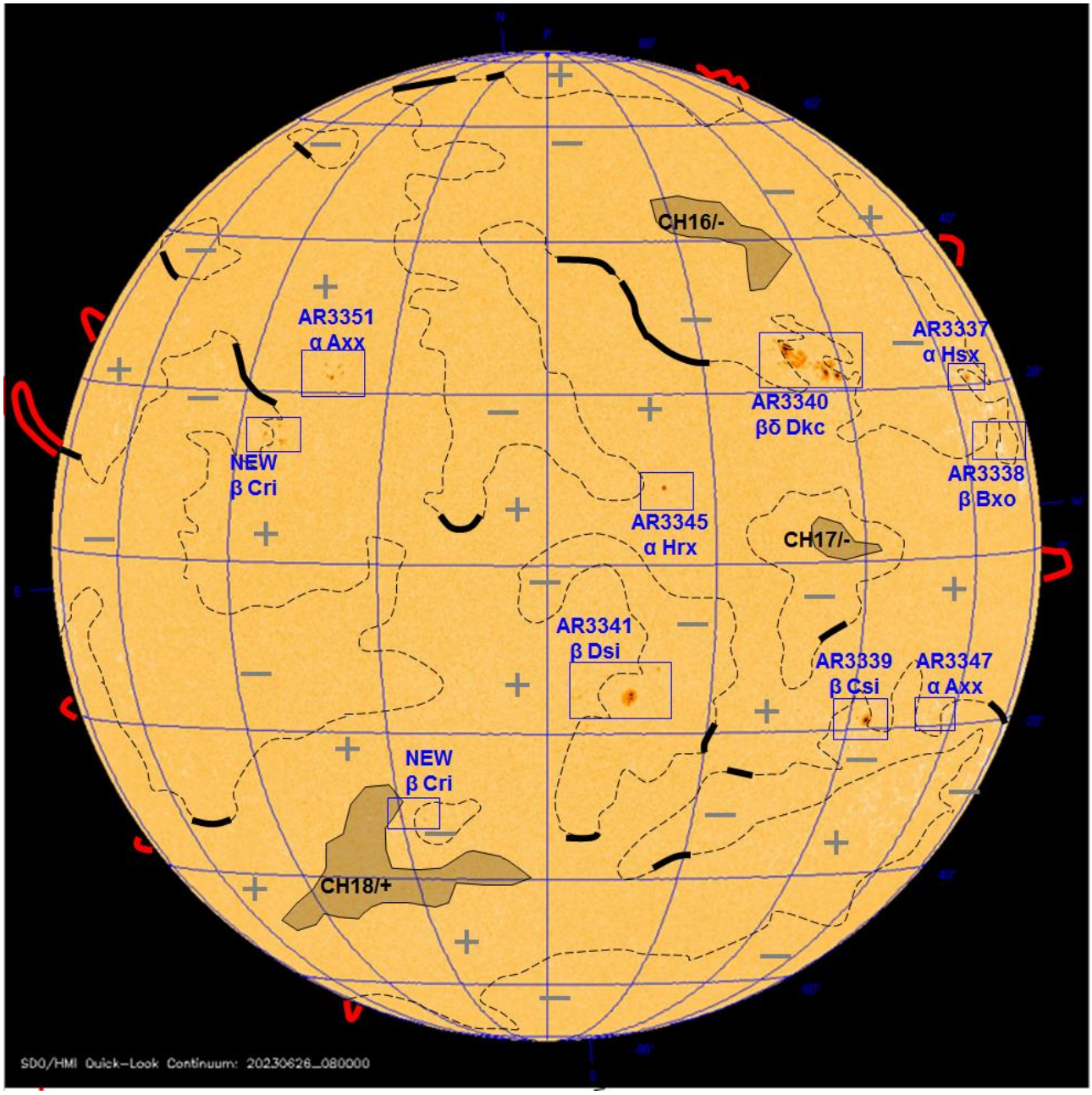
Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels with a very slight chance of rising if any notable flare activity occurs, primarily from AR3340. High energy electron flux (greater than 2MeV) is expected to see current Background to Moderate levels continue. The corresponding 24-hour integrated fluence expected to remain under the Active threshold throughout.

Figure 1. Solar Analysis Valid 0800UTC, 26 June 2023.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

An Earth-directed CME is forecast, initiated by the M4.8 flare from AR3341 in the southeast disc on 22/2344 UTC and the associated filament eruption. The majority of the CME is missing behind and below Earth, likely reaching 1AU early on day 2 (27 Jun) however a glancing interaction is likely as this passes. A coronal dimming associated with a flare from AR3346 in the northwest around 25/2145 UTC may have produced an Earth-directed CME. A minor flare from AR3338 in the far northwest around 25/2030 UTC appears to have resulted in a CME, however it is unlikely to be Earth-directed. There has also been coronal dimming from Ex-3349 in the northeast around 25/1700 UTC, however, no clear CME signature was observed in coronagraph imagery in the hours following the event. Solar winds are slightly elevated 490 km/s due to the ongoing influence of the CME arrival late on 24 Jun. These winds probably declining to around 400km/s in the next 24 hours. The forecast is then low confidence due to uncertain coronal hole and CME analysis. Considering the former, this is due to sunspots in the northwest disc obscuring the view of CH16/-, and also the presence of a very small equatorial coronal hole, CH17/- in the western hemisphere. Enlil suggests that Earth either doesn't encounter the HSS of either region, or that any enhancement is very limited. This is also supported by 27-day persistence. However, given the location of these holes, a potential connection is possible on day 2 (27 Jun) alongside any CME arrival (most likely day 2, but perhaps late on day 1). Geomagnetic activity is expected to be mainly Quiet to Unsettled before activity potentially increases to Unsettled to Active, with a slight chance of G1 Minor Storms. This is most likely on day 2 (27 Jun) with any slight coronal hole enhancement between days 2 to 4 (27-29 Jun) or potential CME arrivals between days 1 and 4 (26-29 Jun).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	10	5	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
23/0714	Partial	M4.8 flare and filament	SE	493 km/s	27/0000UTC +/-12hrs	Low confidence. Glancing impact.

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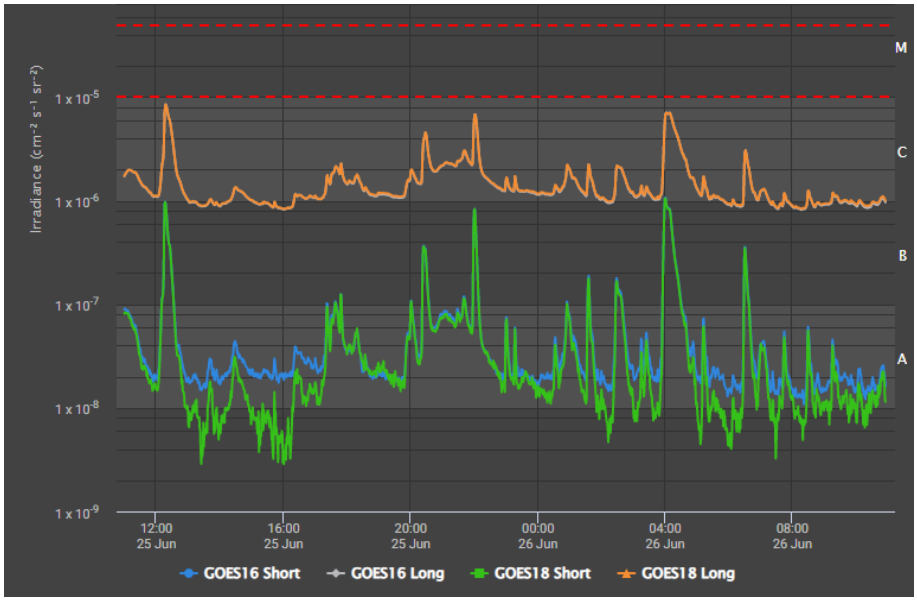
Figure 2: X-ray flux plot at GEO from GOES data with several C-class flares.



Radio Blackouts - X-Ray Flares:

There are ten sunspot regions on the disc with isolated M-flares likely, resulting in Low to Moderate Activity. There is a slight chance that activity could become Strong. The main region of flare interest is AR3340 in the northwest, with continued flux emergence and penumbra development. There are some signs of increased complexity with the looping observed in SDO AIA imagery. A large asymmetric penumbra has formed in the trailer along with a weak delta spot. The region has been the source of a number of C-class flares, and is the most likely source of further significant flare activity. The majority of the other sunspots are smaller, simpler and stable, with a couple of exceptions. AR3337 in the far northwest has produced several C-class flares and a marginal M-flare in recent days. This remains a small and indistinct region, however its east-west aligned magnetic neutral line is typical of unstable regions with an ongoing chance of similar small flares. The area appears to be magnetically connected to AR3338 to the south. AR3341 near the Earth-Sun line in the southern hemisphere was responsible for the largest flare in the past 24-hours with a peak C8.5 flare. This region contains a large H-spot, with a number of very small spots or pores at a distance from the main spot.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	50	50	40	40
Very Active	R3 to R5 X Class	No	10	10	5	5

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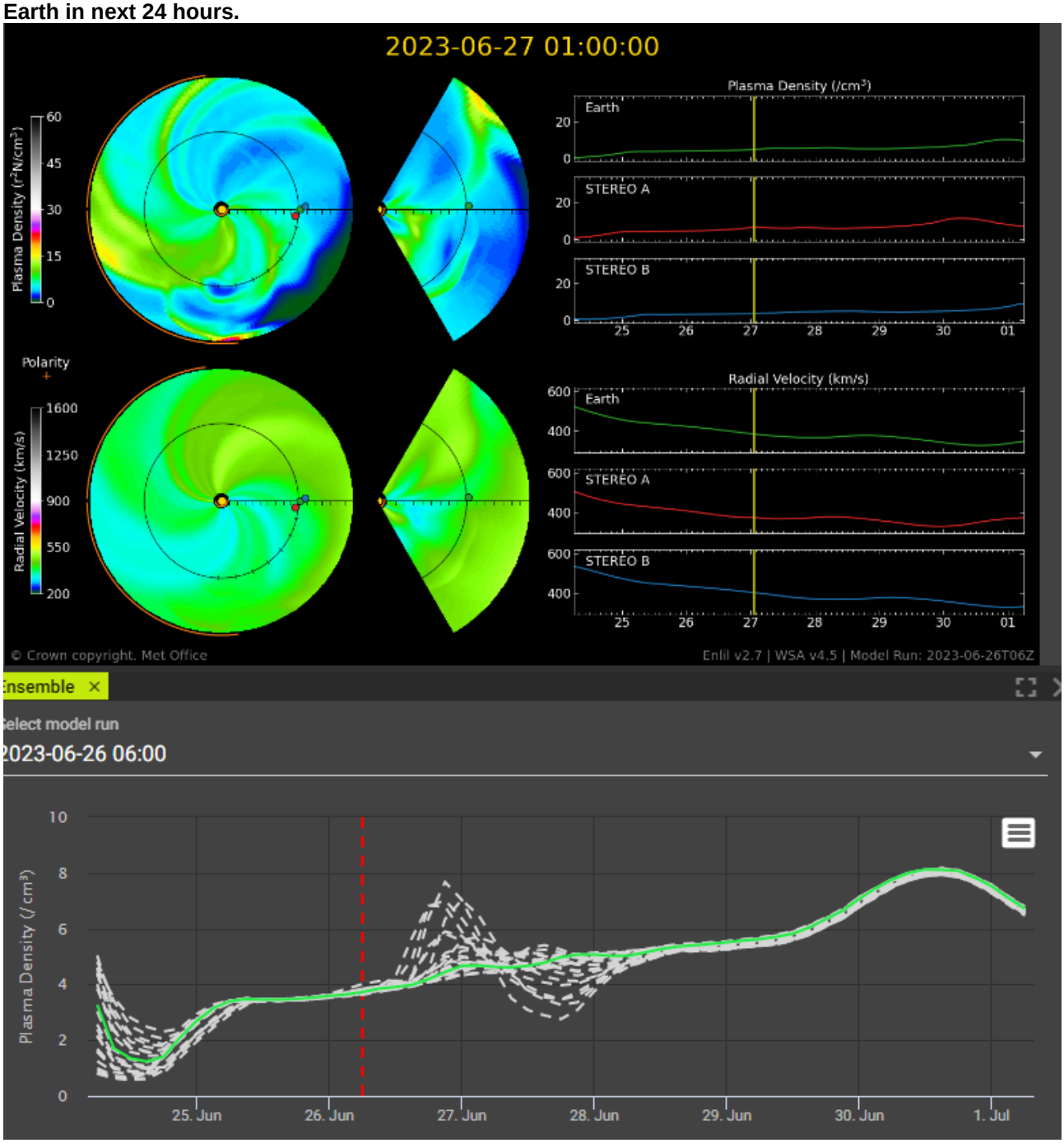
Figure 3: Met Office ENLIL output along with ensemble data showing potential for CME to impact Earth in next 24 hours.



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Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10MeV) proton flux, as observed by GOES16, is at Background levels and expected to remain so throughout the period. This is despite the number of sunspots in the western disc, as they remain small and relatively simple and unlikely to produce significant flares. The possible exception is developing AR3340, which currently provides the main risk of producing any proton events.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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High Energy Electrons Event (≥ 2MeV):

High energy (greater than 2MeV) electron flux is expected to follow its recent trend Background to Moderate, This perhaps rising a little day 1 (Jun 26) as solar winds ease after the recent CME arrival, with a slight chance of briefly reaching High at diurnal max. A further suppression of observed flux is then likely day 2 and into day 3, (Jun 27-28) from any glancing CME or weak HSS arrival, before perhaps rising again towards the end of the period although this is very low confidence by this stage. The associated fluence is expected to remain below the Active level at least until day 3 (27 Jun), This is supported by Met Office REFM output, which gives a good indication of expected fluence in the absence of any further solar wind enhancements and CME arrivals.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	5	5
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 4: High energy electron flux at GEO and Met Office REFM output.

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